Automated One-Dimensional Conductor Generation using the Far Field approach

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Topics

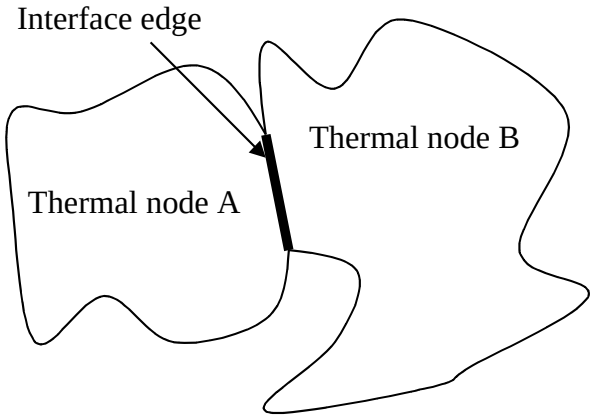
- Why automated linear conductor generation ?
- The Far Field Method
  - Assumptions
  - The method
- Conclusion

Why automated linear conductor generation ?

- 1D-Linear conductors (GLs) in thermal lumped parameter network models are generally calculated by “hand”, with spreadsheets or in some tools with shape specific formulas
- Analytical expressions are only available for a limited number of combinations of simple geometrical shapes which represent the thermal nodes
- Conductor calculation consumes a relatively large part of the thermal model preparation effort
  - In addition it is tedious and error-prone

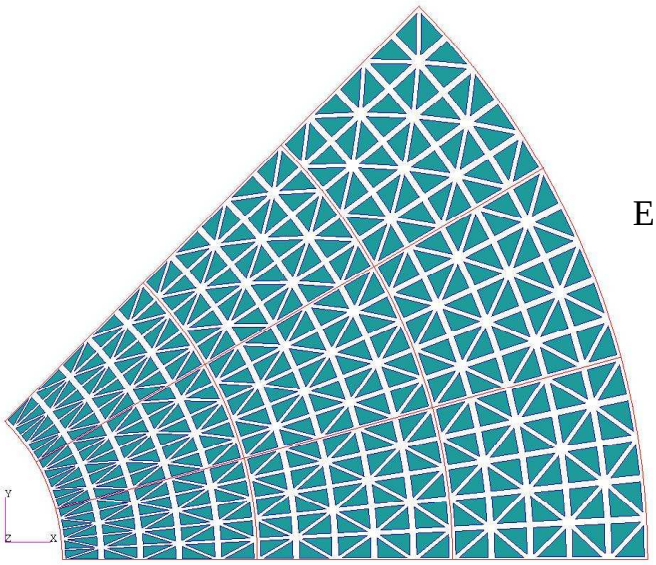
The Far Field Method: Assumptions

- Thermal nodes are considered pair by pair
- Heat is flowing through the two nodes from a remote heat source to a remote heat sink: From one “Far Field” to an other “Far Field”
- The geometry and the properties of the two thermal nodes and their interface are evaluated



The Far Field Method: Assumptions

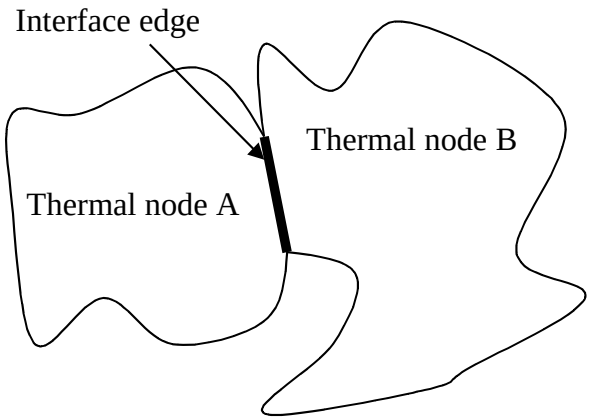
- The geometry can be meshed with a finite element mesh



ESARAD SHELL sub-divided into 9 faces/thermal nodes meshed with finite elements

The Far Field Method: Assumptions

- Adequate representation of interface conductance has to be implemented:
  - Interpolation for non-matching FE-meshes
  - Introduction of contact resistance (if any)

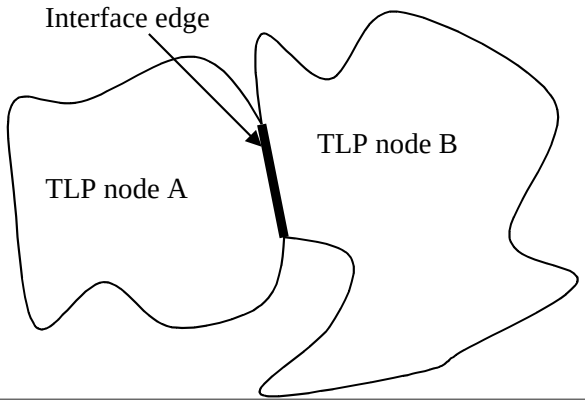


The Far Field Method: The Method

Step 1: Find the FEM-nodes at the “Far Field” edges of the thermal nodes:

“Far Field” edge =

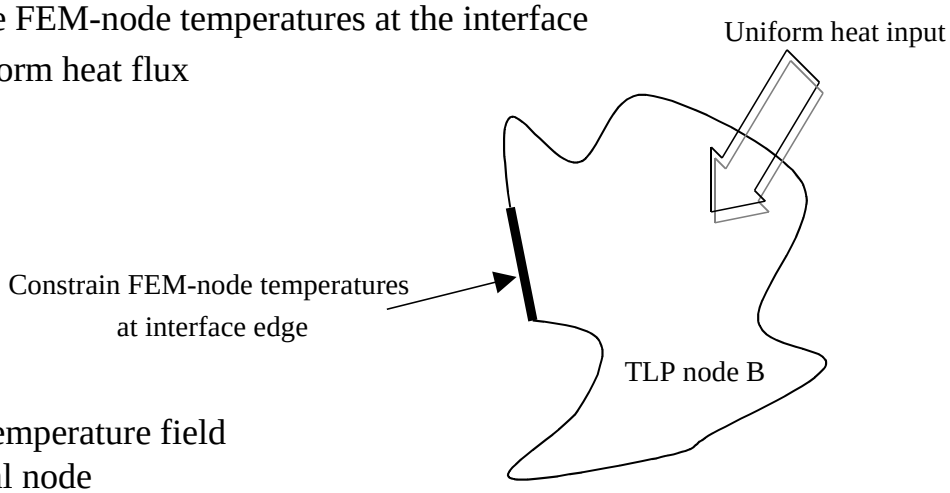
Part of the edge of the thermal node, which has the highest “thermal distance” to the interface



The Far Field Method: The Method (cont’d)

Step 1: Find the “Far Field” edges of the thermal nodes

- Consider a single thermal node and its interface:
  - Constrain the FEM-node temperatures at the interface
  - Apply a uniform heat flux



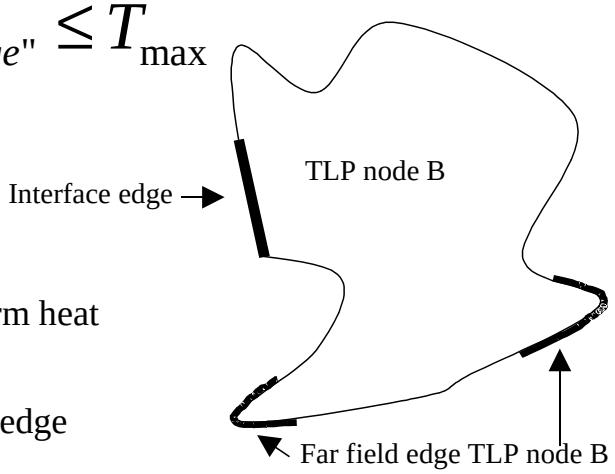
  - Produces a temperature field in the thermal node

The Far Field Method: The Method (cont'd)

Step 1: Find the "Far Field" edges of the thermal nodes

Temperature of FEM-nodes at the Far-Field edge fulfill:

$$T_{\max}\left(1-\varepsilon\right) \le T_{\text{"Far Field edge"}} \le T_{\max}$$



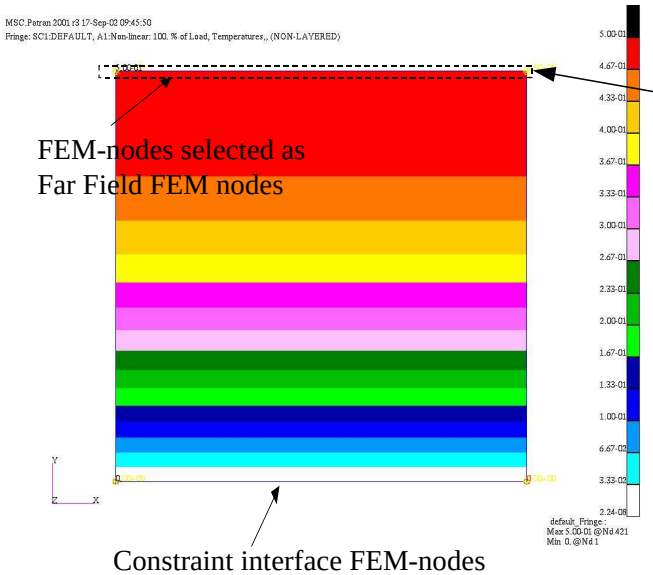
$T_{\max}$ = maximum temperature due to uniform heat flux and constraint at interface edge

ε = tolerance controlling size of Far-Field edge

The Far Field Method: The Method (cont'd)

Step 1: Find the "Far Field" edges of the thermal nodes

Example

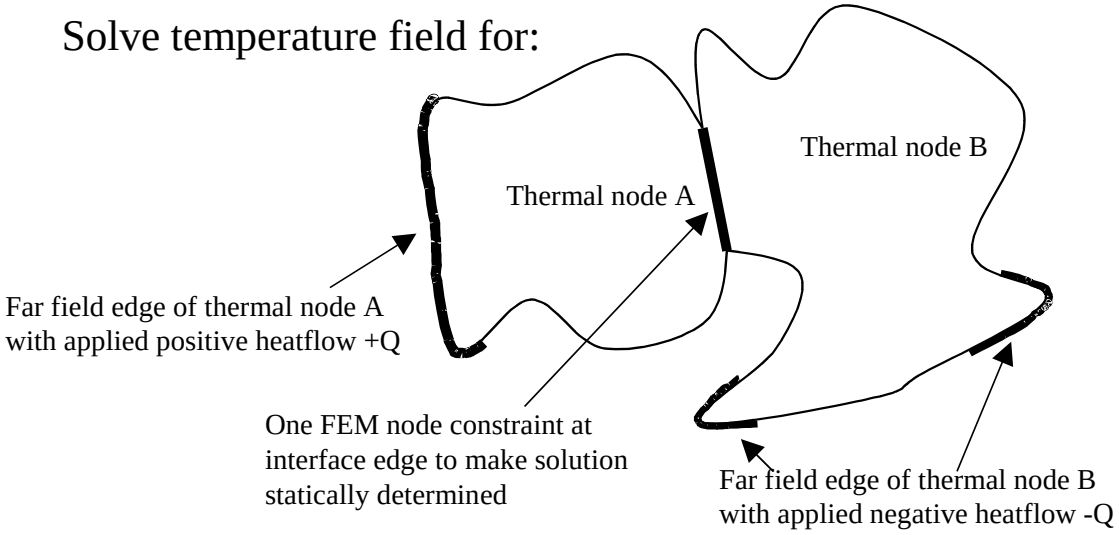


$$T_{\max}\left(1-\varepsilon\right) \le T \le T_{\max}$$

The Far Field Method: The Method (cont'd)

Step 2: Simulate Far Field induced temperature field in two interfacing thermal nodes

Solve temperature field for:

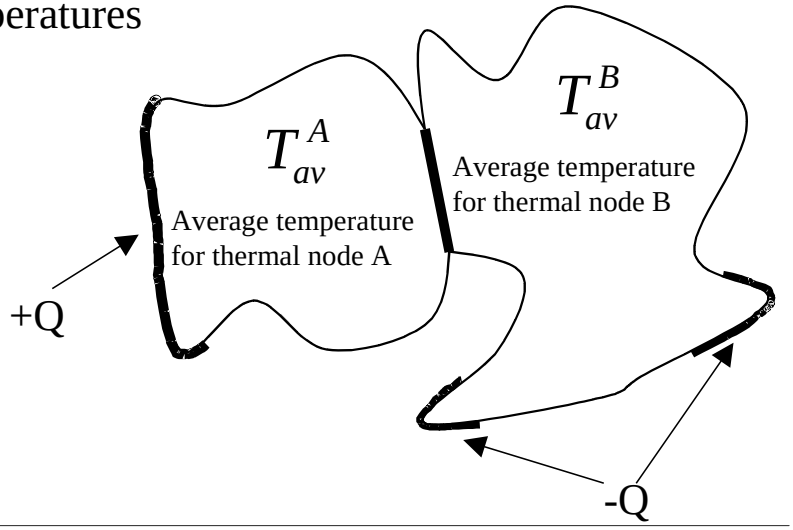


The Far Field Method: The Method (cont'd)

Step 3: Calculate average temperature and conductor value

- Weighted average temperature of the thermal nodes is computed from the FEM-node temperatures

$$GL_{AB} = \frac{T_{av}^{B} - T_{av}^{A}}{Q}$$



Conclusion

- A study has shown the robustness of the method for different geometrical shapes of the thermal nodes
- For simple shape combinations (e.g. rectangle to rectangle) the method converges to the known analytical results
- In the frame of ongoing work Alstom has been given a contract to implement the Far Field method in ESARAD